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This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

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INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Ingo	Speier	Vancouver, British Columbia, Canada

☐ Additional inventors are being named on the ____ separately numbered sheets attached hereto

TITLE OF THE INVENTION (280 characters max)

THERMALLY AND ELECTRICALLY CONDUCTIVE APPARATUS

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Respectfully submitted,

SIGNATURE Carl R Matson

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TYPED or PRINTED NAME Charles R. Matson

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TELEPHONE (303) 352-1134

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THERMALLY AND ELECTRICALLY CONDUCTIVE APPARATUS

FIELD OF THE INVENTION

The present invention pertains to the field of electronic devices and in particular to thermally conductive circuit carriers for use with electronic devices.

BACKGROUND

Effective thermal management is a key factor in ensuring stable electronic device performance over a long lifetime. For electronic devices, a high operating temperature can reduce the lifetime of the devices and their efficacy. In addition, for optoelectronic devices, for example light-emitting diodes (LEDs), the junction temperature thereof can also influence the wavelength of the emitted light. Therefore, effective thermal management of these electronic devices is required.

Adequate cooling may not be achieved by mounting high-powered electronic components to standard laminate boards, for example FR4 boards. This form of board typically does not provide sufficient thermal conductivity to remove heat from high-powered components in order that they can operate within a desired temperature range. As a result, secondary cooling systems for example, heatsinks or coldplates are often used in conjunction with these laminate boards. While adding a secondary cooling system provides an improvement in thermal management, the thickness of a laminate board can provide a barrier to thermal conductivity.

Incorporating thermal management into printed circuit boards (PCBs) has enhanced the thermal flow between the heat source and the cooling system, resulting in improved thermal management. PCBs may include thermal vias comprising thermally conductive materials such as copper or aluminium that are placed in direct thermal contact with heat-producing components. In metal-core PCBs, the core of the board comprises a thermally conductive metal. These products are effective because they ensure very close proximity between heat-producing electrical components and the thermally conductive material, however, the thermal properties of

such modified PCB boards are typically insufficient for many of today's applications. Hence, more advanced thermal management systems for use with high-powered electronic devices have been developed in order to meet this need.

For example, heat pipes, thermosyphons and other two-phase cooling devices have been designed to remove heat from high-power electrical components in an efficient manner. In these devices, heat is transported away from the heat source by means of a heat conducting fluid inside the device. This device typically has two ends, namely an evaporator end and a condenser end. At the evaporator end the fluid evaporates upon absorption of the heat, travels to the condenser end, and condenses upon release of the heat, wherein this fluid may be water or some other evaporable fluid. Heat pipes and thermosyphons are passive systems, thereby requiring no drive circuitry or moving parts to enable their operation. These devices have proven to be effective in moving heat away from high-powered electronic components, particularly when paired with a secondary cooling system. However, these devices are typically designed to be in contact with metal-core PCBs or other substrates that, while being thermally conductive, typically do not enable thermal management as effectively as the heat pipes. As such, benefits of a heat pipe are typically not optimized, as there is a thickness of a less thermally conductive substrate between the heat-producing element and the heat pipe.

A number of literature references disclose the use of thermally conductive devices for use with a heat sink apparatus. For example, United States Patent No. 4,106,188 discloses a package that uses direct cooling of high power transistors by incorporating the components into a heat pipe. The devices are mounted on the inside wall of a heat pipe such that they become part of the wall structure. Electronic circuitry is included, but does not allow for complete functionality of the devices. In addition, the invention does not discuss how to effectively thermally manage mounted optoelectronic devices for example LEDs or lasers, which are mounted on an exterior surface.

United States Patent No. 6,573,536 and United States Patent Application Publication No. 2004/0141326 disclose a light source comprising LEDs mounted to the side of a hollow thermally conductive tube that uses air as the cooling medium wherein the air flows in one direction inside the tube. Electrical connections to the LEDs can be achieved through conductive paths disposed on an electrically insulating layer. These conductive paths can be provided by

means of one or more flexible printed circuits that are placed on the surface of the tube. The means of placing the flexible printed circuits on the surface of the tube however, is not disclosed. Specifically in this prior art the thermal management design and the electrical subsystem are conceived as two separate components and not as one integrated system.

International Publication No. WO 03/081127 discloses a Cooled Light Emitting Apparatus that utilizes a combination of heat pipe and thermoelectric coolers to dissipate heat created by high power LEDs. In this invention, the LEDs are mounted on a heat spreader plate, which is in thermal contact with a thermoelectric cooler, and which passes the heat to a heat pipe or other heat exchange system. For this system, the thermoelectric cooler requires a current passed through it in order to activate the cooling function.

United States Patent Application Publication No. 2001/0046652 discloses a Light Emitting Diode Light Source for Dental Curing. This publication discloses simple circuitry in the form of one electrically conducting layer and one electrically insulating layer that are deposited on one side of a thermally conductive substrate possessing machined trenches that are used to create simple circuitry. The substrate is in contact with a thermally conductive member such as a heat pipe. The LEDs are mounted directly to the substrate, assuming it to be electrically conductive. Control electronics and LEDs are separated and no reference is made to mix accompanying electronics with high-power devices on a single substrate.

International Publication Nos. WO 2004/038759 and WO 2004/011848 disclose a method and apparatus for using light emitting diodes for curing composites and various solid-state lighting applications. In this invention, one or more LEDs are mounted either directly on a heat pipe or on a substrate that is in thermal contact with the heat pipe. The invention discloses integrating circuitry through substrate patterning and through the utilization of printed circuit boards in close contact with the heat pipe.

United States Patent Application Publication No. 2004/0120162 discloses a light source that may be used as part of a dental curing lamp. It discloses LED dies that are placed on a substrate that is in contact with a heat exchanger. However, this prior art reference does not disclose the integration of electronic circuitry necessary to drive the LEDs.

United States Patent No. 5,216,580 discloses an optimized integral heat pipe and electronic circuit module arrangement. It proposes a ceramic substrate carrying electronic components on one side and metallization and a wick structure on the opposing side. The heat pipe comprises an attached matching structure containing a vapour chamber filled with evaporative fluid. The substrate material of this invention is limited to ceramics, and this invention is also limited to the placement of specific electronic devices on such a heat pipe and doesn't include optoelectronic elements such as LEDs or lasers.

While there are many electronic device substrates that incorporate highly thermally conductive systems, the design of such substrates is essentially planar which limits the number of components per useable substrate area that can be thermally managed. Therefore, there is a need for a new apparatus that unifies thermal conductivity and electrical conductivity with an added possibility for enhanced package densities.

This background information is provided to reveal information believed by the applicant to be of possible relevance to the present invention. No admission is necessarily intended, nor should be construed, that any of the preceding information constitutes prior art against the present invention.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a thermally and electrically conductive apparatus. In accordance with one aspect of the present invention there is provided a thermally and electrically conductive apparatus to which one or more electronic devices can be operatively connected, the apparatus comprising: a thermally conductive element in thermal contact with the one or more electronic devices; and a multilayer system including two or more layers, said two or more layers being alternating electrically insulating and electrically conductive layers integrally formed on a portion of the thermally conductive element, said electrically conductive layers providing one or more paths for supplying electric current to the electronic devices.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1a illustrates a cross-sectional view of an apparatus according to one embodiment of the

present invention, wherein an electronic device is mounted directly on the thermally conductive element.

Figure 1b illustrates a top view of the embodiment according to Figure 1a wherein the thermally conductive element has a circular cross section.

Figure 1c illustrates a top view of the embodiment according to Figure 1a wherein the thermally conductive element has a square cross section.

Figure 2a illustrates a cross sectional view of a thermally and electrically conductive apparatus according to one embodiment of the present invention, wherein multiple electronic devices are mounted directly on the thermally conductive element.

Figure 2b illustrates a top view of the embodiment according to Figure 2a.

Figure 3a illustrates a cross sectional view of a thermally and electrically conductive apparatus according to one embodiment of the present invention, wherein the thermally conductive element is immersed in a heat dissipation system.

Figure 3b illustrates a top view of the embodiment according to Figure 3a.

Figure 4a illustrates a cross sectional view of a thermally and electrically conductive apparatus according to another embodiment of the present invention, wherein an electronic device is mounted on the multilayer coating system of the apparatus.

Figure 4b illustrates a top view of the embodiment according to Figure 4a.

Figure 5a illustrates a cross sectional view of a thermally and electrically conductive apparatus according to another embodiment of the present invention, wherein multiple electronic devices are mounted on the multilayer coating system of the apparatus.

Figure 5b illustrates a top view of the embodiment according to Figure 5a.

Figure 6a illustrates a cross sectional view of a thermally and electrically conductive apparatus according to another embodiment of the present invention, wherein a separation layer is located between the heat dissipation system and the layered structure thereabove.

Figure 6b illustrates a top view of the embodiment according to Figure 6a.

Figure 7a illustrates a cross sectional view of a thermally and electrically conductive apparatus having a multilayer coating system on one side of a board shaped thermally conductive element according to another embodiment of the present invention, wherein one or more electronic devices are connected to the side of the apparatus.

Figure 7b illustrates a cross sectional view of a thermally and electrically conductive apparatus having a multilayer coating system on both sides of a board thermally conductive element according to another embodiment of the present invention, wherein one or more electronic devices are connected to the side of the apparatus.

Figure 8 illustrates a cross sectional view of a shaped thermally and electrically conductive apparatus according to one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Definitions

The term "electronic device" is used to define any device wherein its level of operation is dependent on the current being supplied thereto. An electronic device comprises light-emitting elements, laser diodes and any other devices requiring current regulation as would be readily understood by a worker skilled in the art.

The term "light-emitting element" is used to define any device that emits visible, infrared, or ultraviolet electromagnetic radiation because of electroluminescence, for example a semiconductor, organic or polymer light-emitting diode or other similar device as would be readily understood. It would be obvious to someone skilled in the art that elements that emit such forms of radiation may also be used if desired in the present invention in place of or in combination with each other.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by someone of ordinary skill in the art to which this invention belongs.

The present invention provides a thermally and electrically conductive apparatus that can provide both thermal conductivity and electrical conductivity for one or more electronic devices connected thereto. The apparatus comprises a thermally conductive element that is in thermal contact with one or more electronic devices and optionally in contact with a heat dissipation system. A portion of the thermally conductive element is surrounded by a multilayer coating system comprising two or more layers. The multilayer coating system includes alternating electrically insulating and electrically conductive layers in order to provide paths for the supply of electric current to the one or more electronic devices. A conductive layer of the multilayer coating system may be selectively patterned to connect to one or more electronic devices. In this manner, the combination of an electronic circuit carrier and a thermally conductive element can unify thermal conductivity with the provision of power and/or communication into a single integrated unit for use with electronic devices.

The apparatus according to the present invention can be compact in design and can achieve effective thermal management. It can also be implemented in a modular format. Circuitry and other electronic components can be placed on one or more of the layers of the multilayer coating system such that heat can additionally be transported away from those elements by the thermally conductive element, thereby enabling the provision of thermal management to an entire system, for example. The provision of circuit paths to the multilayer coating system can reduce the need for external circuit boards for association with the apparatus, thereby resulting in a reduced size of the apparatus and allowing for increased density of these apparatuses in a prescribed area. In one embodiment the thermally and electrically conductive apparatus can provide an electronic circuit carrier, a support structure for one or more electronic devices, a thermal connector to a heat dissipation system and a mating electrical connection to a support structure that can provide power and/or communication to the electronic devices.

The present invention also applies efficient heat removal technology implemented in both active or passive thermally conductive elements, for example heat pipes and thermosyphons, forced convection cooled systems including fluid cooled cold plates or micro channel coolers, or thermoelectric cooling with the integration of an integrated electrically conductive substrate. High-power electronic devices and optoelectronic devices, for example high flux light-emitting elements, can be placed on the thermally conductive element that can also carry the required

circuit traces and possibly further components required for the operation of the electronic devices. The reliability of the electronic devices can be improved as the thermally conductive element can reduce the thermal resistance of the system and thereby provide lower device operating temperature conditions. The integration of electronic circuitry with the thermally conductive element provides a modular design such that the unit can be connected to a supporting structure that can supply power, communication and access to a heat dissipation system.

One embodiment of the present invention is illustrated in Figure 1a. A thermally conductive element (TCE) **101** is surrounded by a multilayer coating system of alternating electrically conductive **103** and electrically insulating layers **102** and **104**. The numbers and sequences of layers of the multilayer coating system can be different from the ones illustrated and can be dependent on the desired functionality of the multilayer coating system. One or more electronic devices **105** are in contact with the TCE and further electronic devices **110** may be attached to the multilayer coating system.

Thermally Conductive Element

Heat generated by electronic devices that are in thermal contact with a thermally conductive element can be removed and transferred through the thermally conductive element. In one embodiment, the thermally conductive element is connected to a heat dissipation system.

The thermally conductive element may be formed in a number of different shapes for example a pin, a planar element, a curved element, a cylinder, paraboloid, ellipsoid or any other desired shape. In addition, the thermally conductive element can have a variety of cross-sectional shapes for example circular, parabolic, elliptical, prismatic or rectangular. Figures 1b, 1c, 7a, 7b and 8 illustrate various views of example shapes of thermally conductive elements.

Furthermore, in different embodiments, a thermally conductive element may be selected as one of or a combination of heat pipes, thermosyphons, micro channel and macro channel coolers, or active cooling designs including thermoelectric coolers and forced convection coolers, for example.

The thermally conductive element can be made of an electrically conductive or an electrically insulating material. For example, a thermally conductive element can be made of copper, a copper alloy, aluminium or a different metal, or a ceramic material, provided that the selected material is thermally conductive. When mounting high-power electronic devices to the thermally conductive element it can be advantageous to match the thermal expansion coefficient of the material from which the thermally conductive element is formed to that from which one or more of the electronic devices are manufactured. For example, for an electronic device like a LED die, a material that can satisfy this requirement is a combination of copper and tungsten, Cu/W.

Multilayer Coating System

A multilayer coating system is formed on a thermally conductive element, wherein the system comprises one or more layers and the one or more layers are alternating electrically conductive and electrically insulating layers and all layers provide a desired level of thermal conductivity. For example, an appropriate electrically conductive layer can be formed from copper, aluminium or other electrically conductive material. An appropriate electrically insulating layer can be formed from a suitable polymer or ceramic. One or more of the layers of the multilayer coating system may be patterned to provide electrical circuit traces, solder pads, vias or other means to provide electronic connection between one or more electronic devices and the appropriate electrically conductive layer. For example, through the provision of circuit traces in or on the one or more of the layers of the multilayer coating system, electronic devices can be controlled individually controlled or in one or more groups. Furthermore, one or more layers may be patterned to mount additional electronic components, or may provide an electrical interface to external power and control, for example. As illustrated in Figure 2b, each electronic device connected to the thermally conductive element, is electrically connected to an individual circuit trace **220** thereby enabling individual control of each electronic device.

In one embodiment of the present invention, the thermally conductive element is a tubular heat pipe and the multilayer coating system may be formed only on the end of the heat pipe. Optionally, the multilayer coating system may be formed at the end portions or all of the sidewall sections of the thermally conductive element. Furthermore, the thermally conductive element can be fully encased by a multilayer coating system. Embodiments of these configurations are illustrated in Figures 1a, 2a, 3a and 4.

The electrically insulating layers can be formed from materials including silicon oxides, silicon nitrides, alumina, CVD diamond or other materials as would be readily understood by a worker skilled in the art. Optionally, ceramic slurries for example those suitable for the fabrication of metal-core PCBs may also be used to form the electrically insulating layers. The thickness of the one or more electrically insulating layers in the multilayer coating system can be designed in order that their thermal resistance is within a desired range, thereby potentially minimising their effect on the thermal transmission between an electronic device and the thermally conductive element.

The layers forming the multilayer coating system can be deposited on a thermally conductive element using a variety of deposition techniques, for example chemical vapour deposition (CVD), physical vapour deposition (PVD), atomic layer deposition (ALD), dip coating, electroplating, screen printing, or other techniques of thin-layer deposition known in the art.

In a number of different embodiments of the present invention, the multilayer coating system provides direct access to one end of the thermally conductive element, for example as illustrated in Figures 1a, 2a and 3a. In other embodiments of the invention, the multilayer coating system fully surrounds one end of the thermally conductive element as illustrated in Figures 4a, 5a and 6a. The multilayer coating system can be configured in order that it has a desired minimal thermal resistance to heat transfer between the one or more electronic devices and the thermally conductive element.

Interface

In one embodiment, the thermally and electrically conductive apparatus can be interconnected to a support structure. The thermally and electrically conductive apparatus can have mechanical indexing features to provide a reliable and consistent electrical connection to the support structure. For example, electrical circuit traces can be patterned such that upon insertion of the apparatus into a suitable support structure the indexing features ensure that the exposed traces are in contact with corresponding traces on the support structure or heat dissipation system that supplies power and/or communication signals to the apparatus. A form of this indexing of the thermally and electrically conductive apparatus is illustrated as **112** and **212** in Figures 1a and 2a

respectively, wherein the multilayer coatings are appropriately formed in order to interconnect with desired layers on the support structure in a mating manner, for example.

In one embodiment, the thermally and electrically conductive apparatus is modularly attachable to a support structure. The support structure can comprise a heat dissipation system, an electrical interface and a circuit board. In addition, the thermally and electrically conductive apparatus can be clamped, screwed, bolted, or keyed, and have indexing points such that it can be inserted into or detached from the support structure in a predetermined and repeatable fashion. In another embodiment, the thermally and electrically conductive apparatus can be permanently glue bonded, soldered, or welded to a support structure.

The degree to which the thermally and electrically conductive apparatus is encapsulated or inserted into a support structure or a heat dissipation system can vary across embodiments of the invention. For example as illustrated by Figure 3a, the thermally and electrically conductive apparatus can be almost fully immersed within a support structure or heat dissipation system.

In one embodiment, the one or more electronic devices can be mounted directly to the surface of a thermally conductive element, as illustrated in Figures 1a and 2a, thereby providing substantially the lowest thermal resistance to heat transfer between the electronic device and the thermally conductive element. In this configuration the thermally conductive element may be electrically conductive and therefore the portion of the thermally and electrically conductive apparatus that is within or in contact with the support structure of the heat dissipation system can be coated with an electrically insulating layer in order to avoid electrical connectivity between the thermally conductive element and the heat dissipation system. An example of this configuration of the apparatus is illustrated in Figure 2a. Additional electronic devices **210** or electrical components can be mounted either directly to the thermally conductive element or mounted on circuitry that is electrically insulated from the thermally conductive element.

In another embodiment, the one or more electronic devices are electrically insulated from the thermally conductive element by an electrically insulating layer of the multilayer coating system, as illustrated in Figures 3a, 4a, 5a and 6a. The electrically insulating layer or layers separating the electronic devices from the thermally conductive element may be optimized for minimal thermal resistance. The electrically insulating layer may or may not extend into the region that is

in contact with the support structure as illustrated in Figures 2a and 5a, respectively. In the configuration illustrated in Figure 2a, the thermally conductive element can be electrically active as an electrically insulating layer of the multilayer coating system is provided between the thermally conductive element and the support structure.

With reference to Figure 1a an embodiment of the present invention is illustrated having particular regard to the cross sectional region wherein a thermally conductive element (TCE) **101** is in contact with a heat dissipation system or support structure **106**. The TCE is surrounded by a multilayer coating system of alternating electrically conductive **103** and electrically insulating layers **102** and **104**. The numbers and sequences of layers of the multilayer coating system can be different from the ones illustrated and can be dependent on the desired functionality of the multilayer coating system. One or more electronic devices **105** are in contact with the TCE. The substrate can additionally have other electronic devices **110** attached thereto.

Another embodiment of the present invention is illustrated in Figures 2a and 2b where electronic devices **205**, for example light-emitting elements, are bonded **230** to and are in contact with one end of the TCE **201**. Connection from the electronic devices to the electrical traces can be achieved through wire bonding or other techniques known to people skilled in the art. The second end of the TCE is surrounded by a layer **202** of material or a compound that provides a set of predetermined functionalities.. These functionalities can include but are not limited to electrically insulating the TCE from the heat dissipation system or support structure **206** and increasing the interface surface area between the TCE and the heat dissipation system or support structure. In one embodiment, the TCE itself can be used to provide a path for the supply of electric current to the electronic devices. Embedded in the multilayer system can be traces **220** or vias (not shown) that provide paths for the supply of electrical energy to the electronic devices individually or in groups. Furthermore, additional electronic devices **220** may be connected to the apparatus as required.

In another embodiment of the invention as illustrated in Figures 3a and 3b, the TCE **301** can be fully embedded in the heat dissipation system **306** such that part of one end of the TCE is available for mounting electronic devices **305** thereto via the multilayer coating system **341**. The heat dissipation system **306** can have a circuit carrier **340** thereon in the form of a PCB board or a

multilayer coating system, for example. The thermally and electrically conductive apparatus may be reversibly connected to the heat dissipation system. In this embodiment, the electronic devices may need an enhanced heat sink capability that can be provided by this configuration of the interconnection between the TCE and a the heat dissipation system. The electronic devices can be connected to the circuit carrier provided on the heat dissipation system in various ways for example, directly wirebonding **331** or indirectly by mating of appropriate layers of the multilayer coating system **341** with the circuit carrier **340** wherein an electronic device can be wirebonded to the thermally and electrically conductive apparatus. Other connection techniques would be known to worker skilled in the art. The TCE can be a detachable module or an integral part of the heat dissipation system or the TCE can be an extension of the heat dissipation system, for example.

Additional embodiments of the invention are illustrated in Figures 4a, 4b, 5a, and 5b. In the embodiments of Figures 4a, 4b, 5a and 5b the TCE, **401** and **501**, and the respective one or more electronic devices, **405** and **505**, are separated by a multilayer coating system. The electrically insulating layers can achieve electrical insulation of the TCE from the active electronic devices while providing a desired thermal conductivity between the electronic devices and the thermally conductive element. As illustrated in Figure 4a, an electronic device can be electrically coupled to the multilayer coating system or the thermally conductive element through wirebonding and an appropriately designed via, for example. Alternate electrical connections would be readily understood by a worker skilled in the art. The multilayer coating system can be fabricated from thermally conductive materials thereby enabling heat to be transferred from the one or more electronic devices to the TCE. In addition, the thickness of each of the electrically conductive and electrically insulating layers of the multilayer coating system may be designed to improve the thermal contact between the electronic devices and the TCE. The multilayer coating system can have any number or sequence of electrically insulating and electrically conductive layers such that the electrically conductive layers provide paths for the supply of power and/or communication to the electronic devices. As illustrated in Figures 4a and 5a, the thermally and electrically conductive apparatus can be coupled to a heat dissipation system **406** and **506**, respectively.

Figure 6a and 6b illustrate a variation of the configuration illustrated in Figures 5a and 5b, wherein the circuit carrier **620** associated with a heat dissipation system **606** may have a separation **650** there between for the placement of additional material layers or support structure components, for example. In this embodiment, the electronic devices **605** can be electrically connected to either the thermally conductive element **601** or a conductive layer **603** of the multilayer coating system though a wirebond **630** to an appropriately designed bond pad **603** for example. A worker skilled in the art would readily understand alternate electrical connection techniques.

With respect to Figures 7a and 7b, two more embodiments of the invention are illustrated in which multilayer coating systems comprising alternating electrically conductive **703** and electrically insulating layers **702** and **704** are in contact with a flat TCE **701**. Electronic devices **705** and the TCE **701** can be separated by the multilayer coating system or can be in direct contact through specific clearances or attachment points in the multilayer coating system for heat transfer to the TCE. In addition, electronic devices can be connected to one or both sides of the TCE for example wherein this can be dependent on the desired functionality. One or a combination of sides or ends of the flat TCE can be in contact with a heat dissipation system and connected to a structure providing power and communication, for example or alternately, the ends of the TCE can be coupled to the heat dissipation system.

In another embodiment of the invention as illustrated in Figure 8, a TCE **801** having a predetermined shape is in contact with a heat dissipation system **806** and one or more electronic devices **805**. Under operating conditions, heat from the devices can propagate in either direction along the TCE to the heat dissipation system. In this embodiment, a multilayer coating system **820** is formed on one side of the TCE and comprises a mating interface connection with a circuit carrier **830** for example a circuit board or multilayer coating system **830** that is associated with the heat dissipation system **806**. It would be readily understood that the multilayer coating system on the TCE can cover both sides thereof. In addition, the circuit carrier associate with the heat dissipation system can be configured based on the multilayer coating system, for example the circuit carrier may be only provided on one side of the heat dissipation system.

As illustrated in the Figures, the sizes of layers or regions are exaggerated for illustrative purposes and, thus, are provided to illustrate the general structures of the present invention. Once again, as stated previously, various aspects of the present invention are described with reference to a layer or structure being formed. As will be appreciated by those of skill in the art, references to a layer being formed "on" another layer or a thermally conductive element contemplates that additional layers may intervene. Furthermore, relative terms such as beneath may be used herein to describe one layer or regions relationship to another layer or region as illustrated in the Figures. It will be understood that these terms are intended to encompass different orientations of the device in addition to the orientation depicted in the Figures. For example, if the device in the Figures is turned over, layers or regions described as "beneath" other layers or regions would now be oriented "above" these other layers or regions. The term "beneath" is intended to encompass both above and beneath in this situation.

It would be readily understood by a worker skilled in the art that while the Figures illustrate a particular number of layers, each of these identified layers can be formed by a plurality of layers depending on the targeted application or optionally there may be fewer layers within the structure.

It is obvious that the foregoing embodiments of the invention are exemplary and can be varied in many ways. Such present or future variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A thermally and electrically conductive apparatus to which one or more electronic devices can be operatively connected, the apparatus comprising:
   a) a thermally conductive element in thermal contact with the one or more electronic devices; and
   b) a multilayer system including two or more layers, said two or more layers being alternating electrically insulating and electrically conductive layers integrally formed on a portion of the thermally conductive element, said electrically conductive layers providing one or more paths for supplying electric current to the electronic devices.

ABSTRACT

The present invention provides a thermally and electrically conductive apparatus that can provide both thermal conductivity and electrical conductivity for one or more electronic devices connected thereto. The apparatus comprises a thermally conductive element that is in thermal contact with one or more electronic devices and optionally in contact with a heat dissipation system. A portion of the thermally conductive element is surrounded by a multilayer coating system comprising two or more layers. The multilayer coating system includes alternating electrically insulating and electrically conductive layers in order to provide paths for the supply of electric current to the one or more electronic devices. A conductive layer of the multilayer coating system may be selectively patterned to connect to one or more electronic devices. In this manner, the combination of an electronic circuit carrier and a thermally conductive element can unify thermal conductivity with the provision of power and/or communication into a single integrated unit for use with electronic devices.

Fig. 1a

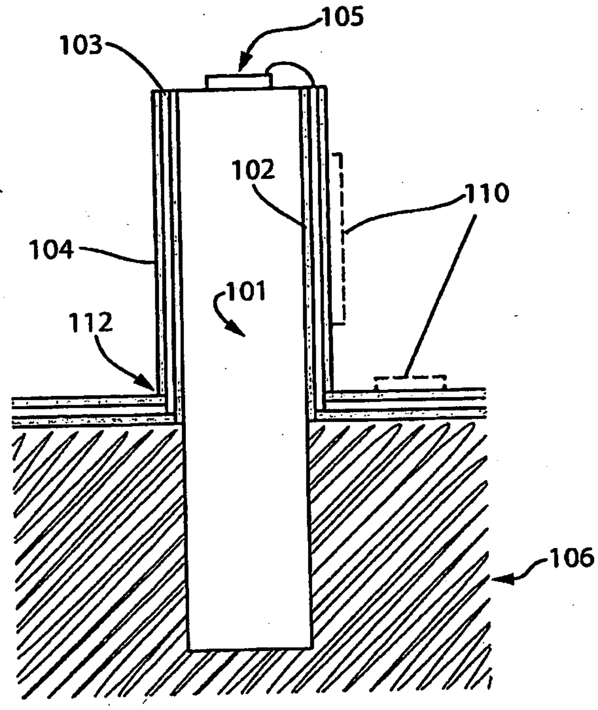


Fig. 1b

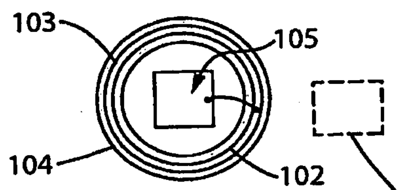


Fig. 1c

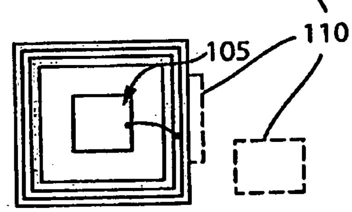


Fig. 2a

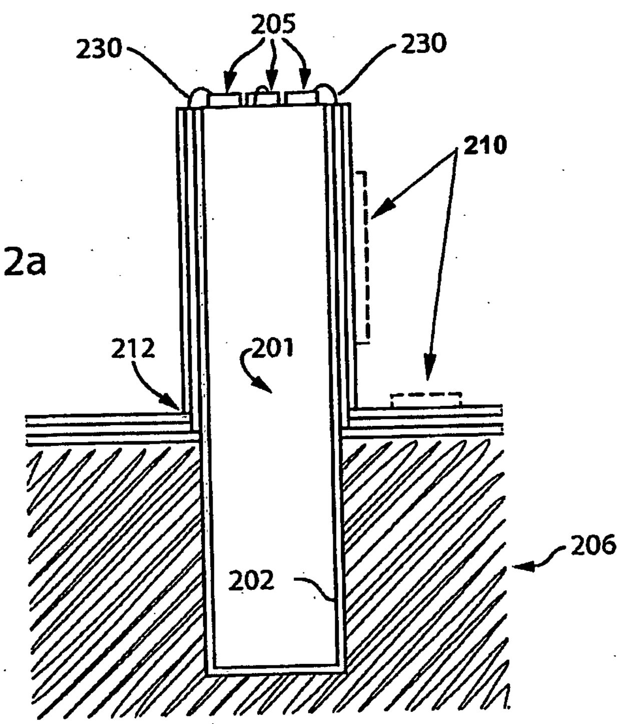


Fig. 2b

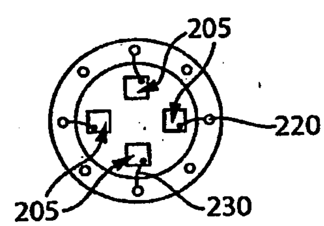


Fig. 3a

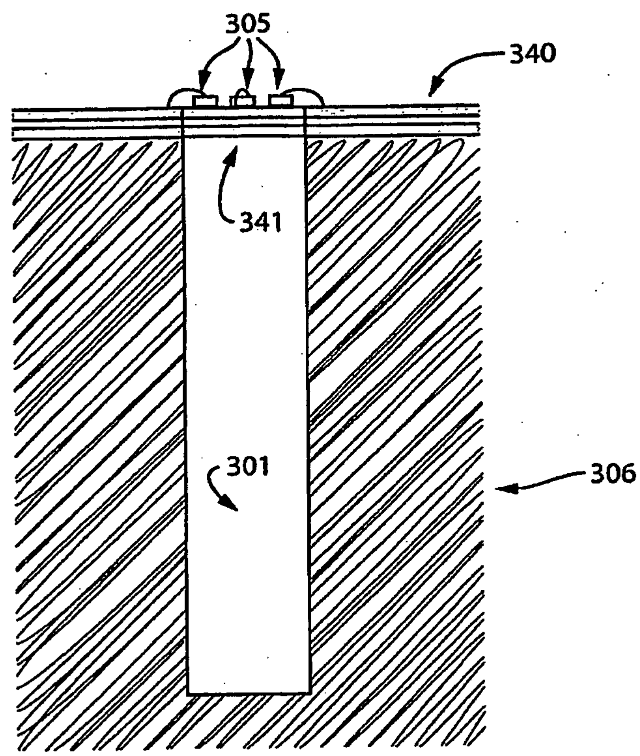


Fig. 3b

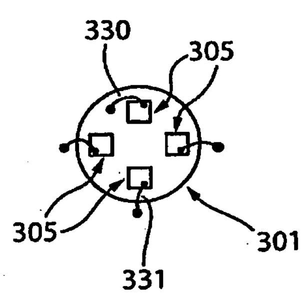


Fig. 4a

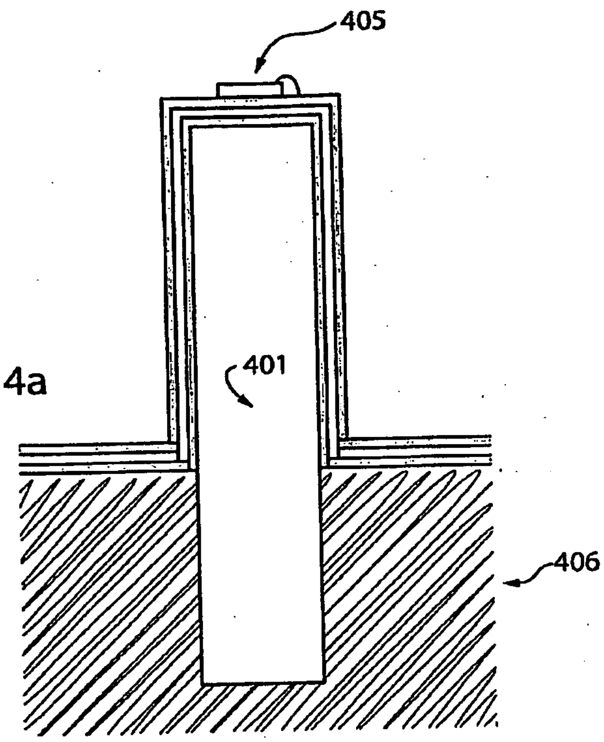


Fig. 4b

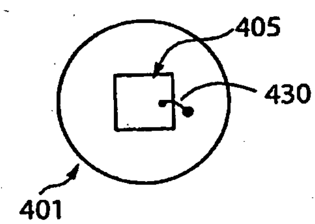


Fig. 5a

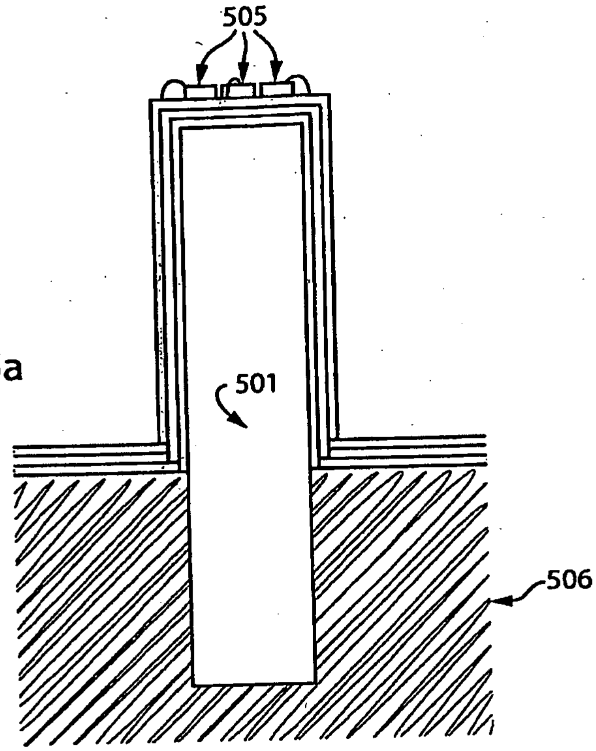
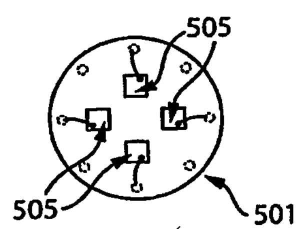


Fig. 5b



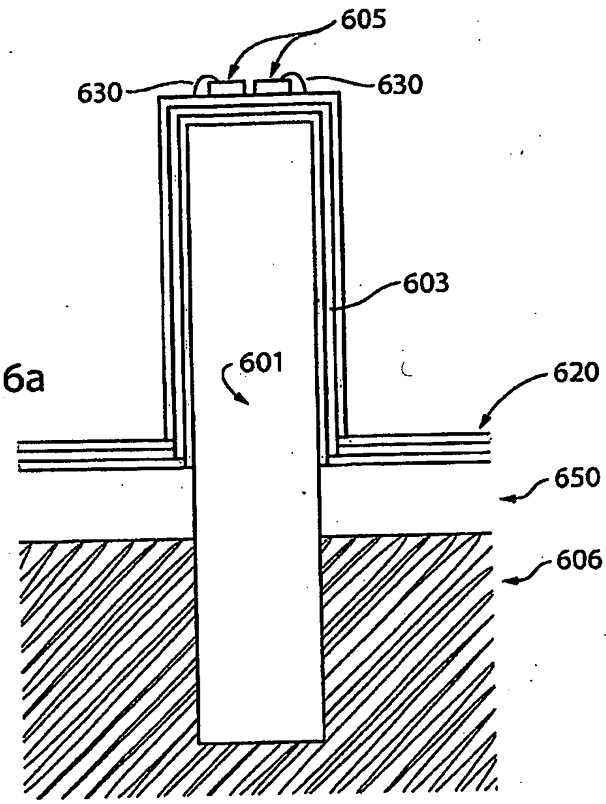


Fig. 6a

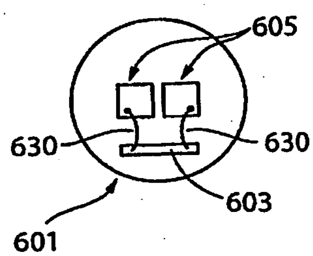


Fig. 6b

Fig. 7a

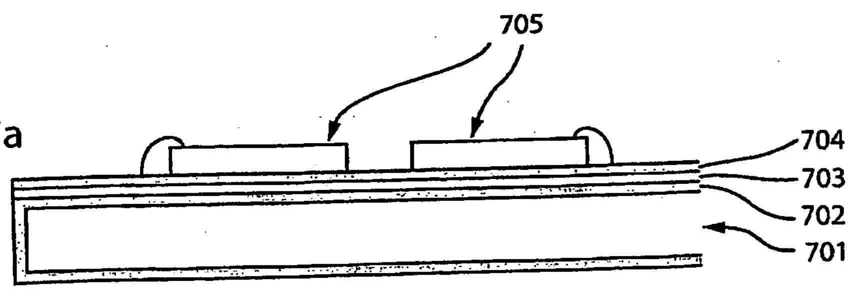
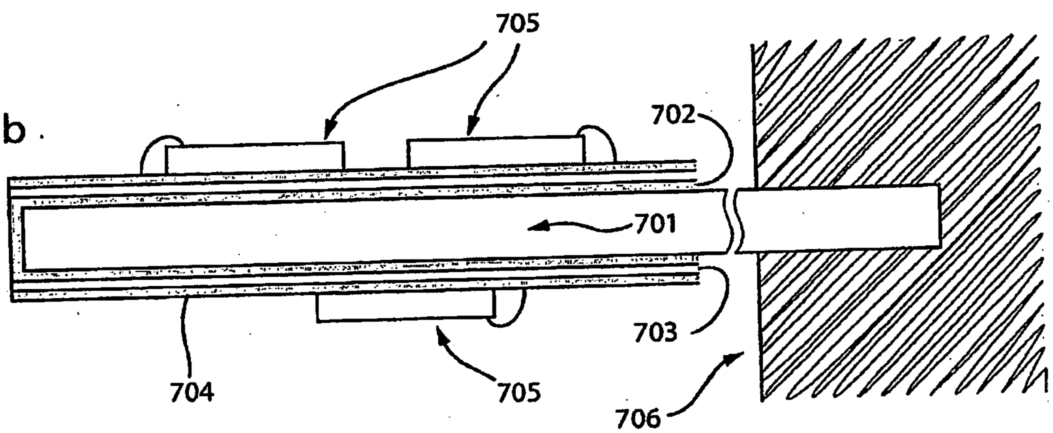


Fig. 7b



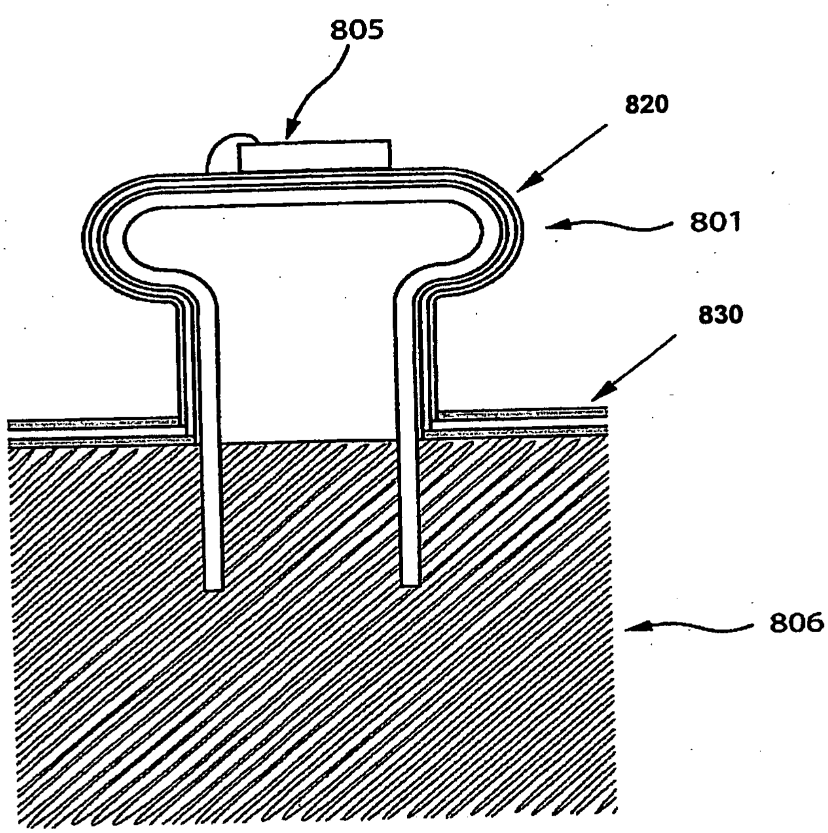


Fig. 8

Docket No. 186198/US
Express Mail No. EV 423776310 US

APPLICATION DATA SHEET

Application Information

Application Type::	Provisional
Subject Matter::	Utility
CD-ROM or CD-R?::	None
Title::	THERMALLY AND ELECTRICALLY CONDUCTIVE APPARATUS
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Request for Non-Publication?::	No
Suggested Drawing Figure::	n/a
Total Drawing Sheets::	8
Small Entity::	No
Petition included?::	No
Secrecy Order in Parent Appl.?::	No

Applicant Information

Applicant Authority Type::	Inventor
Primary Citizenship Country::	German
Status::	Full Capacity
Given Name ::	Ingo
Family Name ::	Speier
City of Residence::	Vancouver
Country of Residence::	Canada
Street of Mailing Address::	2942 Grant Street
City of Mailing Address::	Vancouver
State of Mailing Address::	British Columbia
Country of Mailing Address::	Canada

Docket No. 186198/US
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Correspondence Information

Correspondence Customer No.:: 20686

Phone Number:: (303) 629-3400

Fax Number:: (303) 629-3450

Representative Information

Representative Customer Number::	20686

Foreign Priority Information

Country::	Application Number::	Filing Date::	Priority Claimed::

Domestic Priority Information

Application::	Continuity Type::	Parent Application::	Parent Filing Date::